Space Weather Technical Forecast

Issued on Thursday, 10 March 2022 at 01:02 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1 Minor Geomagnetic Storms day 1 and 2 (10th/11th). Chance of M-class flares. Active Electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low over the period, with activity confined to isolated low C-class flares, primarily from AR2965 Fai/Beta-Gamma on the northeast limb. There are 6 numbered sunspot regions, with AR2964 Dai/Beta and AR2966 Bxo/Beta in the southwest, both small but notable for their reversed polarity for southern hemisphere spots for cycle 25, with the latter recently developing. AR2960 Eho/Beta is a moderately sized, but inactive region in the southern centre disc. The other two regions AR2957 Hsx/alpha and AR2964 Axx/alpha are small and simple. No Earth-directed CMEs were observed in available imagery in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR at L1 was at background to slightly elevated, 380-410km/s with density mostly below average. The total interplanetary magnetic field strength (IMF), Bt, was weak below 5nT, while the north-south component, Bz was predominantly negative with brief positive rotations, but remains weak -3nT to +2nT. Phi angle was mostly negative (towards the Sun). The corresponding geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was at Background levels. The high energy electron flux (greater than 2 MeV) was High throughout, with a peak value of 5130 pfu at 09/1500 UTC. The corresponding 24-hour integrated electron fluence remained above the Active (1e8 integrated pfu) level. The 10/0000 UTC observation was 2.58e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low with further C-class flares, and a chance of rising to Moderate due to the occurrence of any M-class flares. The main risk is likely to be from AR2965, but cannot be ruled out from the other sunspot regions.

Solar Wind / Geomagnetic Activity: There are two CMEs en-route with a potentially Earth-directed component, but with low confidence. The first is from an uncertain source on the 5th, and the second from a filament eruption late on the 6th. Any arrival that occurs is currently expected on the 10th with ongoing influence during the 11th. Confidence is higher for the 2nd of the two, albeit only glancing, but also with a potential for combining into a single arrival. Otherwise solar winds are expected to persist at background to slightly elevated levels. Mainly Quiet geomagnetic activity is forecast. This potentially becoming Unsettled to Active, with a chance of G1/Minor Storm intervals with any CME arrivals at Earth, most likely occurring on day 1 (10th), with ongoing affects day 2 (11th). Quiet conditions then returning day 3 (12th) onward.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, albeit with a very slightly above background risk of rising towards the S1 level. The high energy (greater than 2 MeV) electron flux is expected to be at High levels at first, but likely dropping out with any CME arrival. A return to Moderate to High levels then expected day 3 (12th) onward. The associated 24-hr fluence is expected to remain

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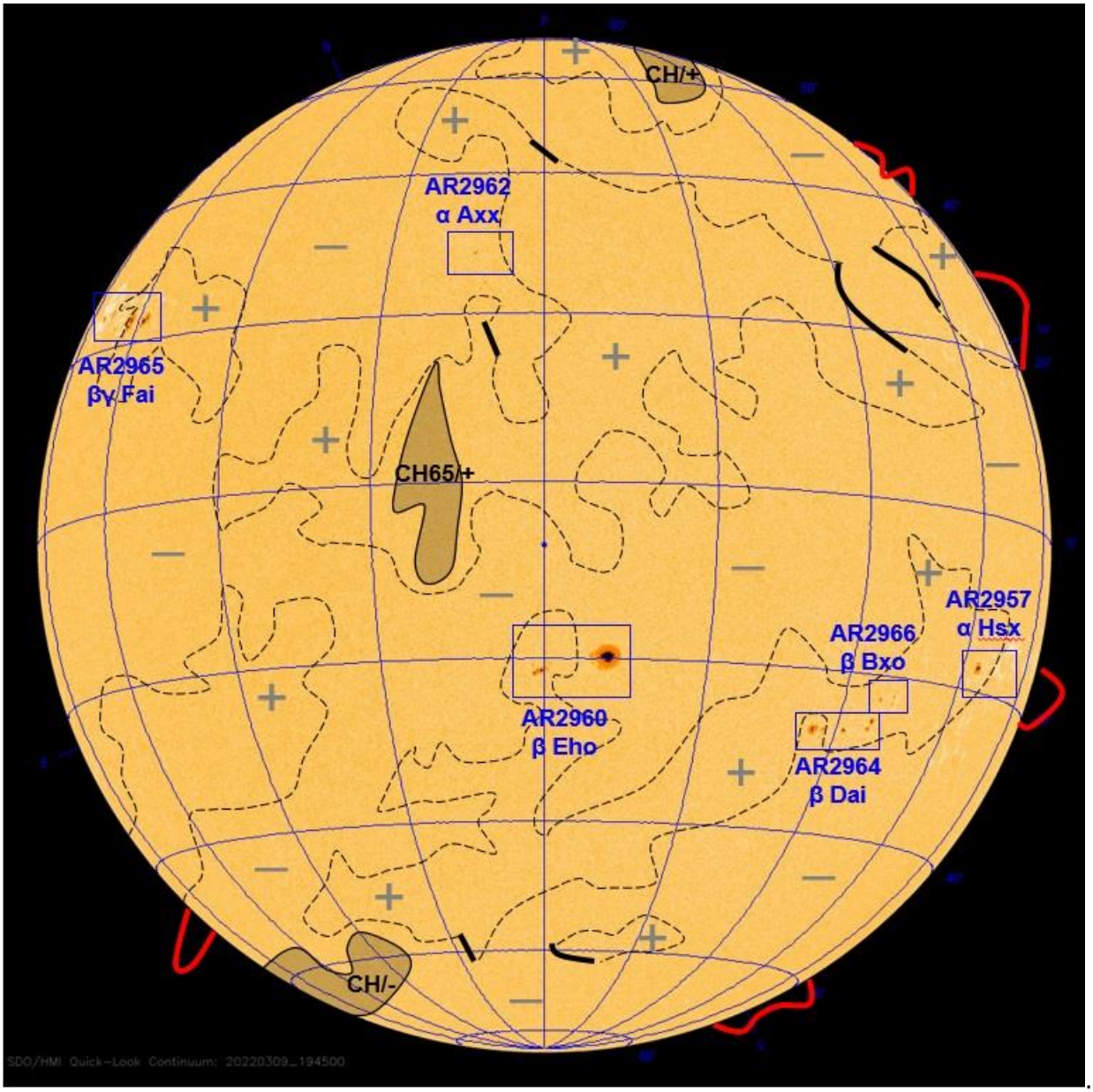
above the Active threshold day 1 and into day 2 (10th and 11th), before likely falling below in response to any drop out. A chance of ongoing Active fluence is maintained day 3 and day 4 however, due to uncertainties around the strength and occurrence of the CME arrivals.

Figure 1. Solar Analysis Valid 09/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two Earth-directed CMEs. The first is a low confidence CME, due to only a weak signal in SOHO LASCO coronagraph imagery and an uncertain source, leaving the Sun on the 5th. The second was due to a filament eruption late on the 6th, and whilst confidence is higher on the analysis, it is lower for Earth-directed impact with only a glancing interaction observed. These CMEs are indicated to arrive on day 1 (10th), perhaps merging into a single arrival.

Confidence is increased however due to news that the Solar Orbiter magnetometer has reported a direct hit from two CMEs whilst in the Sun-Earth line (reported on Twitter). Given a strong negative Bz component was observed, the risk for G1/Minor Storm intervals has been increased, with arrival expected 2nd half of day 1 (10th), and a potential magnetic cloud influence continuing through the (11th).

Otherwise, mainly background to slightly elevated solar winds expected, with the only coronal hole of note on the disc, CH65, not expected to bring any fast wind into Earth until beyond this forecast period.

Mainly Quiet geomagnetic activity is forecast. This potentially becoming Unsettled to Active, with a chance of G1/Minor Storm intervals with any CME arrivals at Earth, most likely occurring on day 1 (10th), with ongoing affects day 2 (11th). Quite conditions then returning day 3 (12th) onward.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	30	30	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
05/1502 UTC	Partial	Unknown	15E 4N	224 km/s	10/1200 UTC	Very low confidence. Could combine with below
07/0920 UTC	Partial	Ex-2958 Filament eruption	24W 10N	417 km/s	10/2100 UTC	Glancing impact expected

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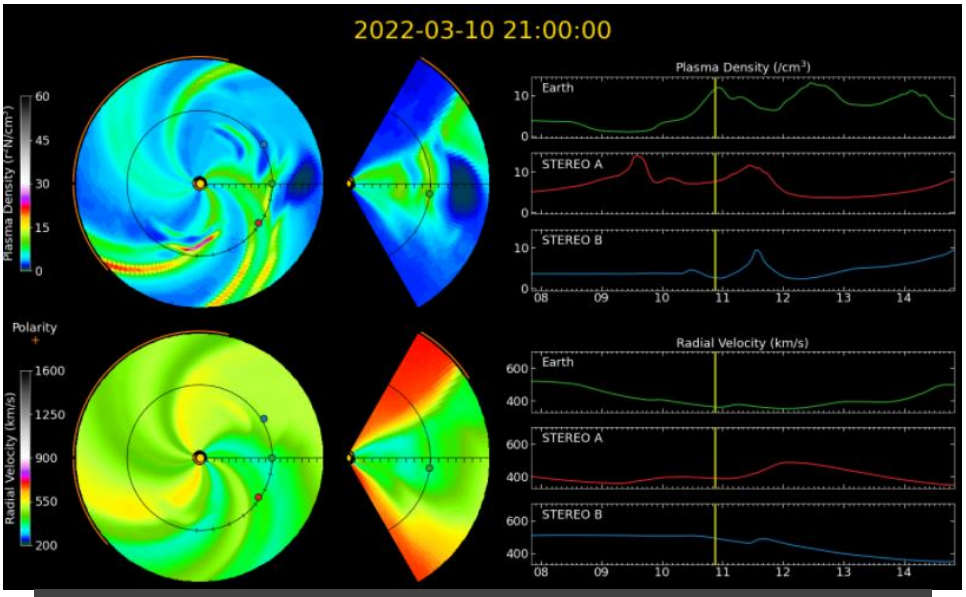
Figure 2: Enlil and ensemble showing potential arrival



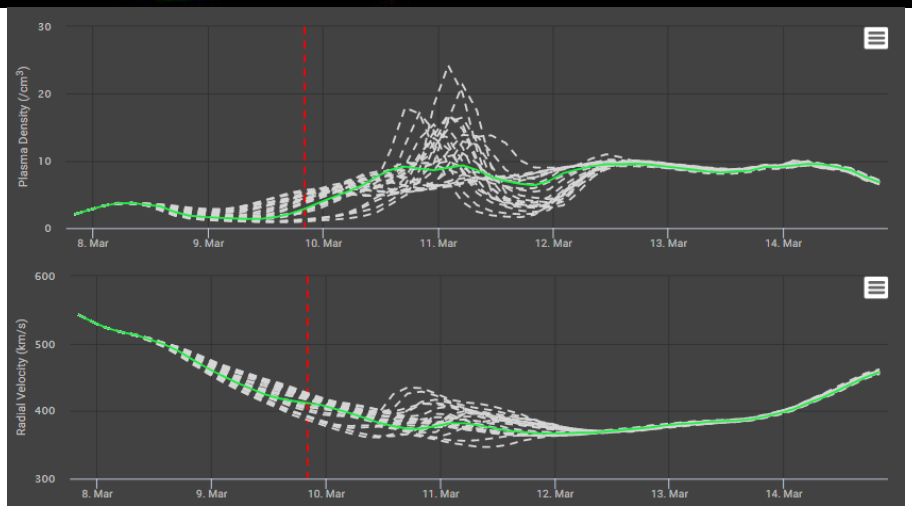
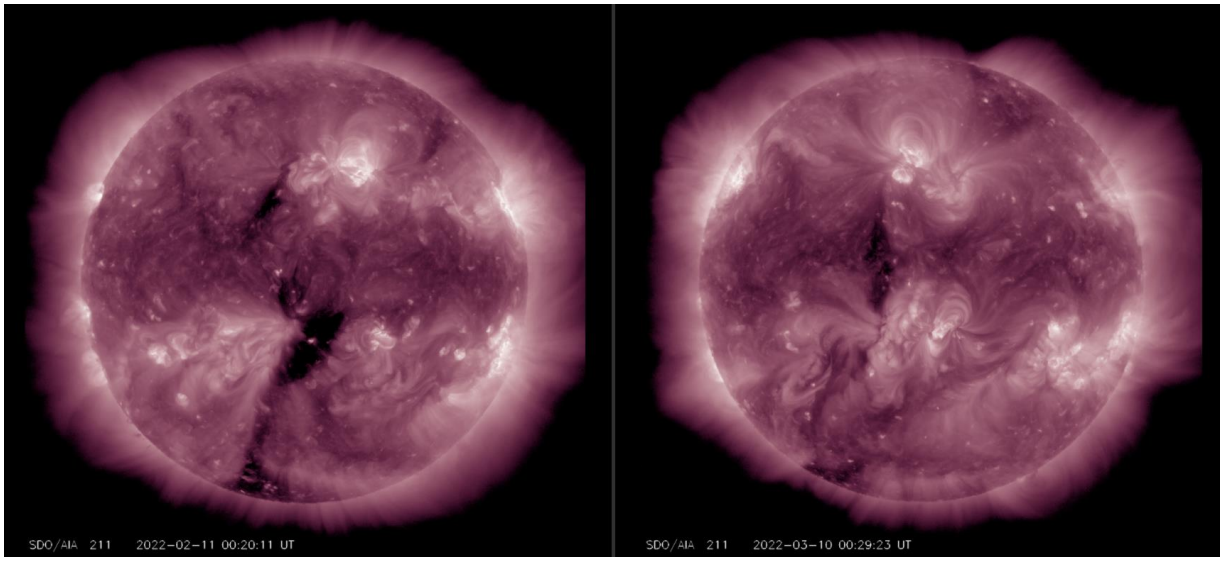


Figure 3: SDO aia 211 of previous rotation (left) and current (right). Marked difference in upcoming CH, but outside forecast period



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Radio Blackouts - X-Ray Flares:

There are currently six numbered sunspot regions on the visible disc, although solar activity has remained Low.

The most notable region is AR2965 Fai/Beta-gamma near the northeast limb. This is an elongated collection of small spots, set amongst an area of plage that has shown some recent development, although this maybe exaggerated due to it rotating into a clearer view. In the southwest disc, there is a further collection of small spots which form two separate but close regions AR2964 Dai/Beta and AR2966 Bxo/Beta, the latter of which only developed in the last 24 hours. Whilst small, these spots are both noteworthy due to a reverse polarity for solar cycle 25 southern hemisphere spots, such that any further development has the increased potential for instability that may result in flare activity. AR2960 Eho/beta in the centre disc has the largest individual spot, with a large leader, but remains stable. The other regions, AR2957 Hsx/alpha and AR2964 Axx/Alpha are small and stable.

Low activity is expected to continue with an 80% chance of further C-flares, and a chance of increasing to Moderate with any M-flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	25	25	25
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 4: GOES-16/17 X-ray flux

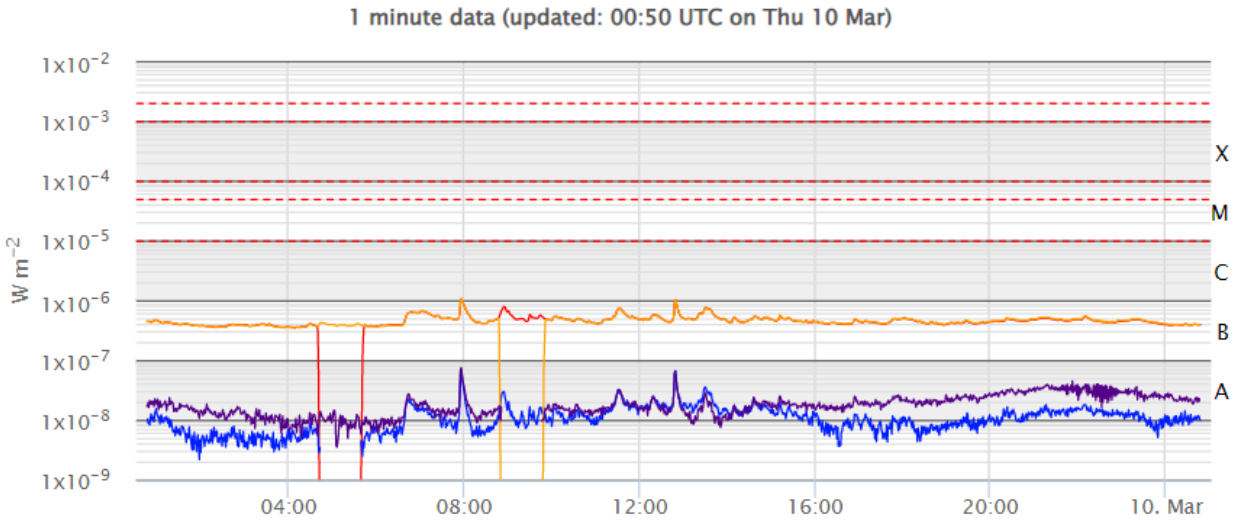

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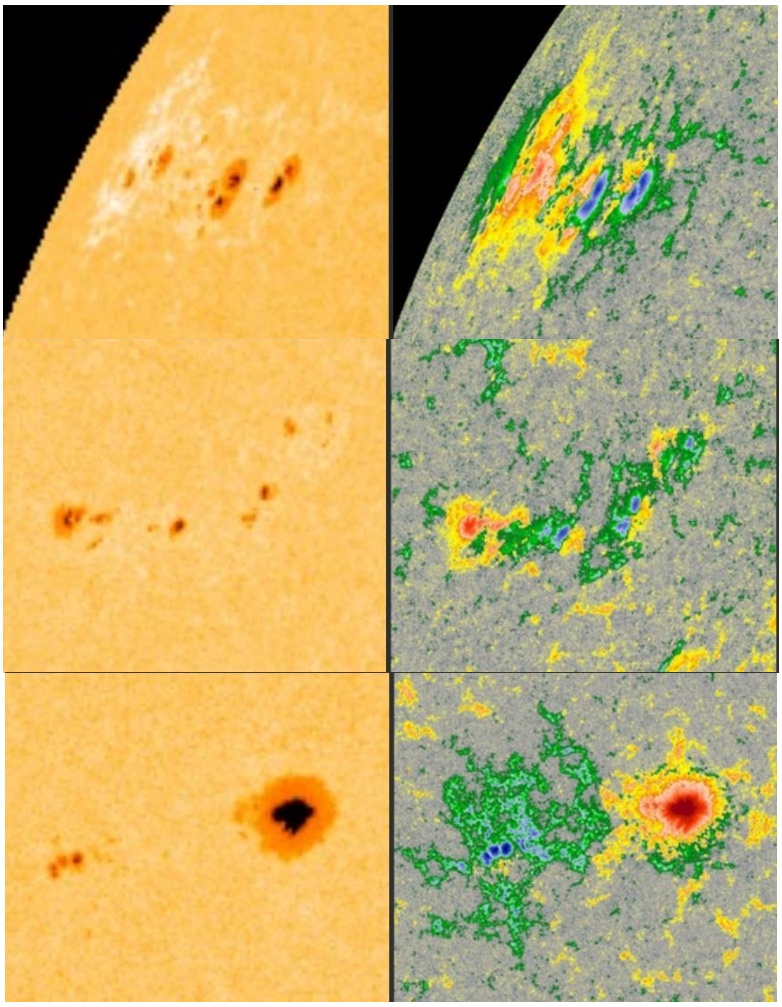
Figure 5: SDO Intensitygram (left) of Magnetogram (right) of AR2965, AR2964/AR2966 and AR2960



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 is currently at background with solar radiation storms not expected. However, the development of AR2966 near AR2964 in the southwest disc, both of which have a reversed magnetic configuration for solar cycle 25, gives a slightly above background risk which is maintained through the period. This is also supported by the development of AR2965 in the northeast, although this is in a much less favourable location for any proton rich flare to result in radiation storms at Earth.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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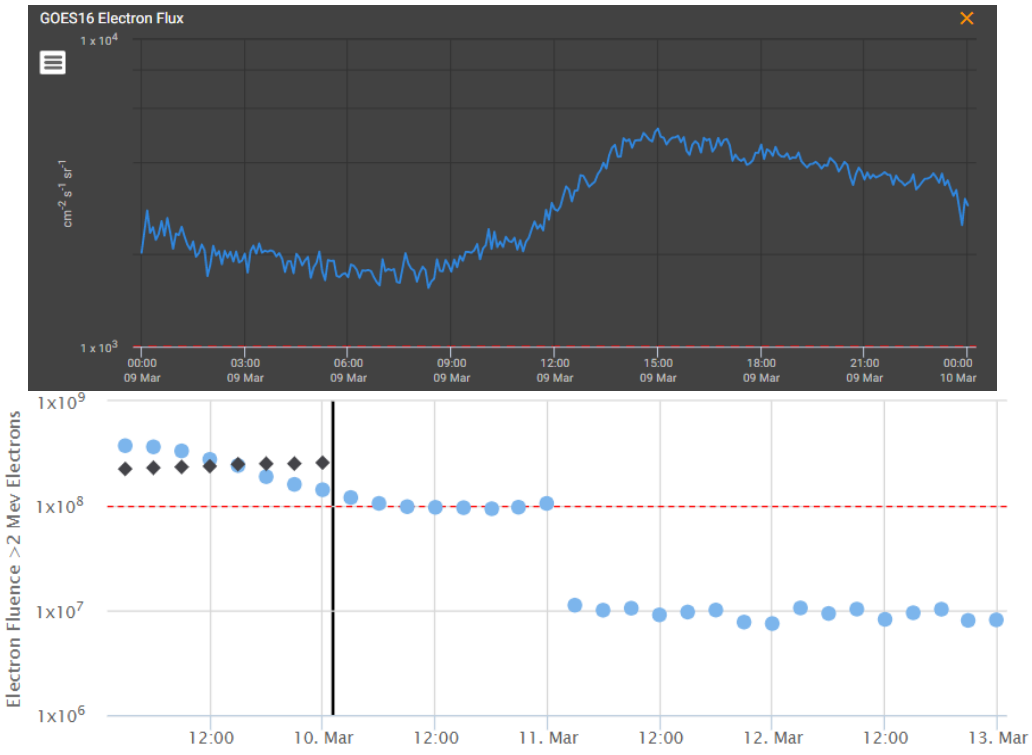
High Energy Electrons Event (≥ 2MeV):

The high energy (2 MeV) electron flux as observed by GOES16 is currently at High levels, and is expected to persist at these values until the arrival of any CME on the day 1 (10th). The occurrence and strength of any arriving CME is low confidence, however if this occurs a drop out in observed flux to background levels is expected. Any recovery is likely to be muted later day 2 (11th), with a chance of Moderate to High flux levels returning day 3 onward (12th).

The associated 24-hr fluence is expected to persist at High levels on day 1 (10th), and also into day 2 (11th) due to the delayed response to the drop out caused by a 24 hour summation period. Through day 2 fluence is then likely to then fall below this threshold, however a risk of maintaining Active levels is maintained day 3 and day 4 (12th and 13th) due to the uncertainty regarding the arrival and strength of any CMEs and their impact on the observed flux at GEO. REFM is currently poor guidance, as it is both underestimating current flux and is also not able to take account of upcoming CME arrivals.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	90	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 6: GOES-16 Electron Flux (top) and REFM (bottom)



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